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Bi-ResNet: Fully automated classification of unregistered contralateral mammograms

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Introduction

Motivated by the fact that the contralateral mammograms can provide the symmetrical difference of the left and right breasts to assist identify the breast cancer, we propose a bilateral residual neural network (Bi-ResNet) that can automatically classify the normality/abnormality based on the unregistered contralateral whole mammograms. Specifically, the parallel ResNet network is designed to simultaneously process a group of contralateral mammograms and respectively capture the discriminative representations from the left and right mammograms, and the concatenation strategy in the final is used to integrate the differentiated features for the abnormal classification task. The proposed Bi-ResNet can achieve reproducible and similar results based on different backbones and is superior to traditional contralateral analysis methods in both automation and performance. Finally, our proposed BiResNet is greatly demonstrated on the publicly available DDSM dataset, a total of 10480 images, yielding the highest AUC of 0.908 on the abnormal classification task. Through the massive experiments, we deem our model is stable and robust, and has the potential to be recommended to clinical application in the future.

Methodology

In clinical practice, radiologists typically detect inconspicuous lesions by global-to-local symmetry difference analysis by comparing the mammograms of left and right breasts, as shown in Fig.1. Motivated by this, an extended version of the deep residual network (ResNet), called Bilateral ResNet (Bi-ResNet), is proposed in this work, and it is able to accept unregistered contralateral mammograms as input and unify the learning of contralateral features and classifier in an end-to-end supervised training fashion for normal/abnormal classification. The architecture of Bi-ResNet is shown in Fig.2

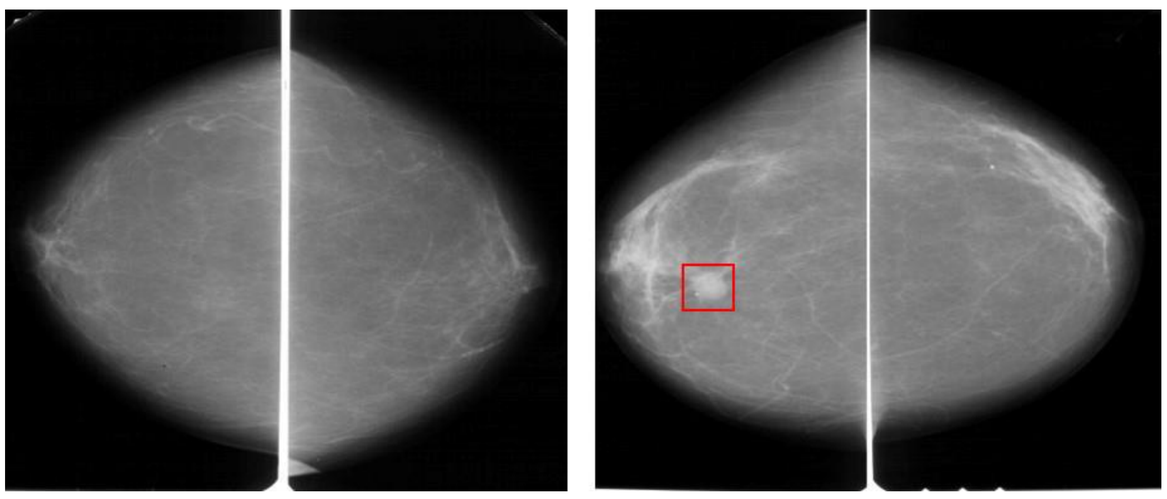

Fig.1. A set of normal (Left) and abnormal (Right) contralateral mammograms. Obviously, there is no obvious discrepancy in the normal contralateral mammograms; on the contrary, significant visual difference occurs in the abnormal contralateral mammograms, where the suspicious lesion marked by the red box in the left breast is not visible in the right breast.

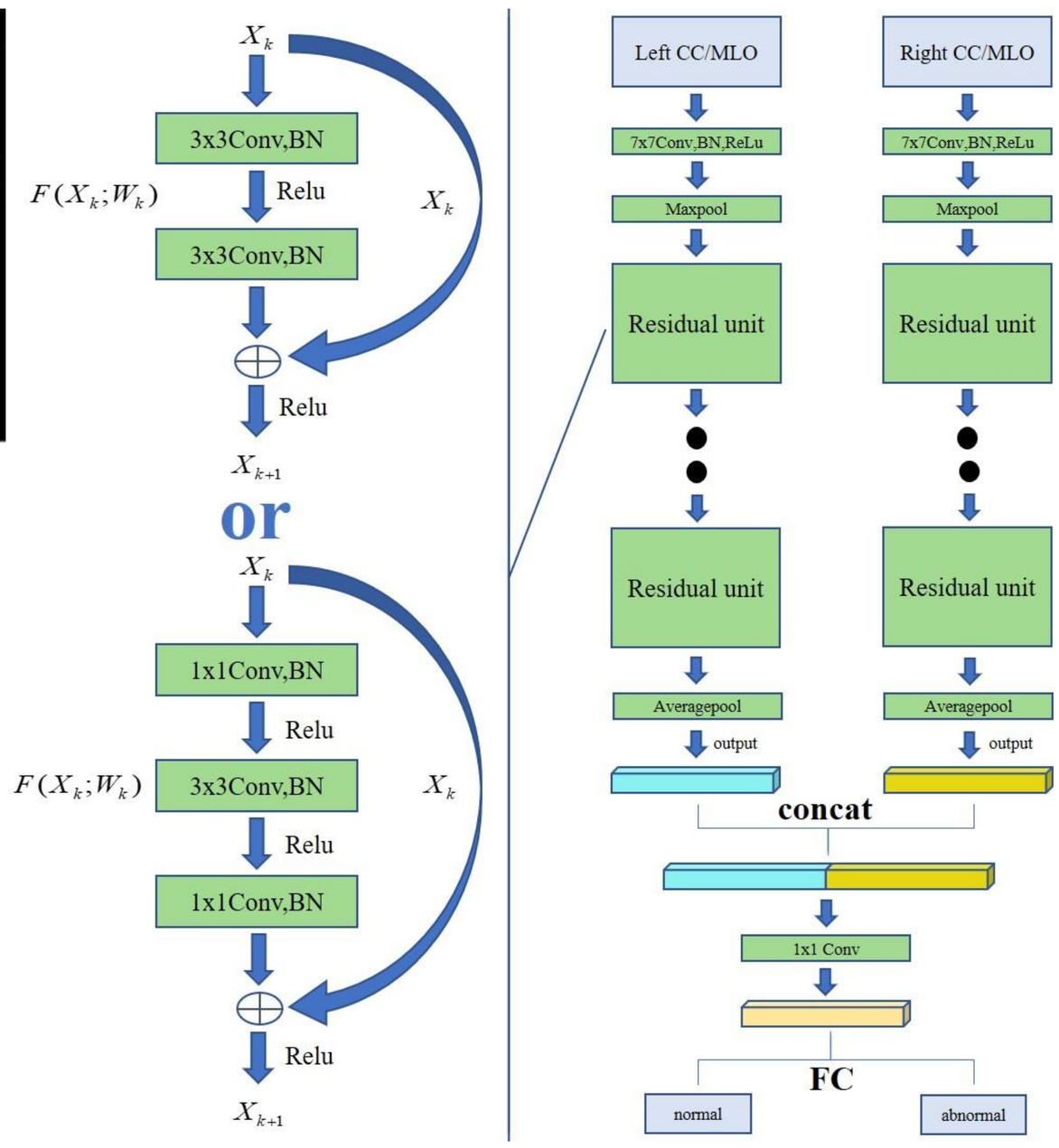

Fig.2. The proposed Bi-ResNet for fully automated classification of unregistered contralateral mammograms. Upper left: a residual unit for ResNet-18/34. Lower left: a residual unit for ResNet-50/101/152.

Experiment Results

- *Comparison with Standard ResNet Series Network.*

In order to verify the effectiveness and robustness of Bi-ResNet, we conduct a set of comparative experiments on each network of the ResNet series. The results are shown in Fig. 3.

- *Comparison with Precious Similar Methods.*

Table 1 presents several similar approaches that incorporate a various type of contralateral analysis, for objectively evaluating the performance of the proposed Bi-ResNet..

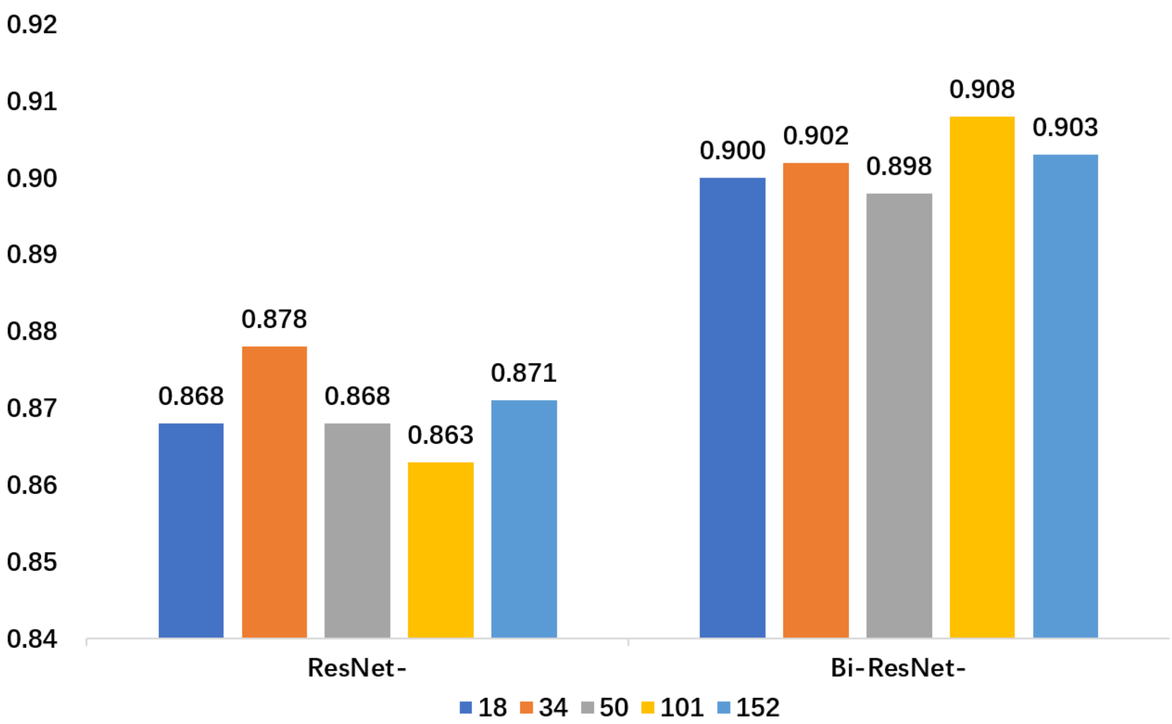

Fig.3. The normal/abnormal classification AUC of ResNet-18/34/50/101/152 and proposed Bi-ResNet-18/34/50/101/152.

Table 1. Performance comparison between several similar contralateral analysis approaches.

Methodologies	Database	AUC
Rodriguez-Rojas et al.	Private database (200 cases)	0.880
Mart´ı et al.	Private database (264 images)	0.760
Zheng et al.	Private database (451 cases)	0.761
Wang et al.	Private database (200 cases)	0.750
Tan et al.	Private database (994 cases)	0.720
Celaya-Padilla et al.	DDSM-Lumisys (88 cases)/BCDR (64 cases)	0.738/0.767
Bi-ResNet-101	Entire DDSM(2620 cases)	0.908

Conclution

In this paper, a novel end-to-end Bi-ResNet is proposed for the fully automated normal/abnormal classification of unregistered contralateral whole mammograms. Comparing with single-view classification based on ResNet series networks, the Bi-ResNet analysis strategy has achieved significant improvement, with a highest and average AUC increment of 0.045 and 0.033, respectively. This result shows that the strategy can achieve reproducible and similar results even with the different backbone networks and proves the effectiveness and robustness of the strategy. Moreover, experiments prove that our proposed Bi-ResNet surpasses traditional contralateral mammograms analysis approaches in terms of the automation degree and classification performance. Finally, the Bi-ResNet-101 is validated in the most commonly used pubic mammographic database DDSM with the highest AUC of 0.908, which indicate that the model could classify normal contralateral mammograms from any other type of cancer or benign abnormality and has the potential to be used in the breast screening programs.

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